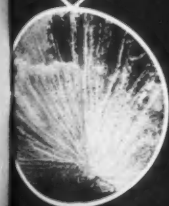


Read Wash-Day Blues

CHEMISTRY



Twisted Molecules.....	1
Back Cover Picture: Feathers Are Protein.....	5
Three Hydrogens Possible for Bombs.....	6
More Efficient Transistors.....	9
Instruments Watch Matter in Space.....	12
Algae May Feed Starving World.....	17
Leaves Brighten Autumn.....	19
For the Home Lab: Bismuth.....	21
Teen Age Scientists.....	23
Selenium Compounds.....	25
Analyzing For All the Elements.....	31
Enzyme Controls Bone Calcium.....	37
Sand in the Gears.....	39
Denim Renaissance.....	41
Inventions Interesting to Chemists.....	42
Book Condensations.....	45
Proudly Presented.....	46

Editorial:

The Living Molecule
Inside Front Cover

50¢

The Living Molecule

► PROCESSES that make life a going concern offer one of the most exciting areas for chemical study. Far below the limits of visibility to which our eyes are sensitive lies the domain of molecular dimensions. Living tissues which seem to change so slowly and to operate so quietly on the microscopic level are revealed by tracer studies to be the resultant of constant reactions. The task of the chemist is not to find the end product of a single reaction, given the starting compounds, and to write the balanced equation.

The problem of life chemistry is one of energy exchange. The energy must reach a certain threshold before a reaction can take place. The reactions that keep life processes flowing must count on the necessary energy supply. The materials constantly flowing to and away from the reacting center must also be available. All these are new ideas to the chemist who used to think in terms of a reaction proceeding from left to right.

Although the world of the molecules remains invisible, much can be done to get around the limitations of our senses and the media by which we see. The techniques of X-ray diffraction and of the electron microscope allow us to see structures forever invisible to ordinary light. Tracer methods using radioactive isotopes allow us to follow the path of an individual atom through a course of reactions in living tissues.

Surprisingly, we find that the forms of things at the sub-microscopic level are familiar. A compact molecule in fact looks round. A long chain compound is very apt to string out into a wispy fiber. A cross-linked structure does in fact stretch out into a film, and the film will have holes in it if there is not enough material to cover the surface which supports it.

The twists in the ultimate fibers of protein, and the set of mathematical formulas which describe them, told about in this issue of CHEMISTRY, are important steps in understanding the nature of one of the most important life chemicals. With this new understanding, Dr. Pauling and his colleagues have a new tool for exploring the mystery of life.

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—Fremont Davis Photo

► *ROPE is the model for the newly-found structure of the protein molecule. In Dr. Linus Pauling's hands the six outer strands of the rope twine around the seventh central one, just as six protein fibers twist around the seventh to make up the structure of a living chemical.*

Twisted Molecules

by HELEN M. DAVIS

► UNRAVELLING the rope-like form of protein, the basic stuff of life, is a puzzle on which American and British scientists are making progress after some three years of hard work. It is like putting together a jig-saw picture. One team contributes a section here. Another sees the chance of a better arrangement there. Excitement grows as the over-all pattern begins to be glimpsed.

Protein is meat, muscle, skin and

hair. It is cell material. It is food. If we are ever to know how living matter is put together we must understand protein. If we can synthesize this chemical perhaps we can create food from simple materials, not dependent on animals. If we know how proteins are formed we can understand how growth takes place and how tissues break down. Perhaps this is the clue to cancer. Possibly we can create living matter in the laboratory. Protein is a puzzle. But a beginning has been made toward solving it.

In Pasadena, at the California Institute of Technology, Dr. Linus Pauling and Dr. Robert B. Corey are solving the problems of structure of individual kinds of protein materials. In England, at the Cavendish Laboratory of Cambridge University, work on the mathematical theory of possible shapes which these protein materials might assume has contributed to the solution of the protein puzzle. Other scientists in both countries are adding to the store of information about this fundamental life stuff.

The method for seeing the structure of proteins is a standard one. It consists of bouncing X-rays off the material to be studied, and then collecting them on a photographic plate. The technique was originally begun about 1911 in Germany by Dr. Max Laue, in order to learn more about X-rays. Later the method was turned around by Dr. W. H. Bragg and his son, Dr. W. L. Bragg, in England. They used X-rays, by then well understood, to tell more about the different kinds of materials which would diffract them.

Using this method, Dr. Pauling and Dr. Corey in California found that protein materials yield irregular patterns of light and dark areas on the photographic plates. But they hit upon the idea that these patterns could be caused by a particular kind of molecular arrangement that would be simple and regular in its own way. They believed that similar patterns to the ones on their X-ray plates would be made by rays projected from different parts of a spirally twisted string of large protein molecules. This gave them the key to the puzzle of protein structure.

Other pieces of the protein picture came into place when synthetic compounds were studied. Compounds made of protein-forming chemical groups were found to show patterns in X-ray diffraction photographs that could come from twisted molecular strings. In the synthetic compounds, chemists have a pretty clear idea of the arrangement of the atoms that make up these molecular strings. They know even how big they are and how far apart. This helped them calculate the amount and direction of the twist.

At this point three British scientists, Drs. W. Cochran and F. H. C. Crick of the Cavendish Laboratory and Dr. V. Vand of Glasgow University, worked out the mathematical theory of such molecules wound into the shape of a helix.

A helix is the shape of a coiled spring or of the turns of wire that form an electromagnet. A rope may be thought of as having the same kind of shape. It is a cylinder in outline. The shape of a cut end is circular. It is the same size at any place along the length of the cylinder. It is made up of one or more fibers twisted by a spiral motion in either a right-hand or a left-hand direction.

The British team have worked out the formulas for the measurements of molecular chains twisted in this manner. They have worked out combinations of these chains twisted around each other like the strands of a rope. They can measure such ropes twined into many different patterns, more varied and more complicated than the cables and hawsers men make out of vegetable fibers.

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—Fremont Davis Photo

► DR. LINUS PAULING, *California Institute of Technology*, has worked out the twisted form of the protein molecule. He is applying the mathematical formulas which measure this structure to many kinds of protein materials occurring in nature.

NOVEMBER 1953

formulas, Dr. Pauling and Dr. Corey are analyzing the X-ray diffraction patterns of many kinds of protein materials. Other scientists also are trying the method. A whole new area of understanding about chemical structure has opened. Such materials as skin, hair, horn, feathers and claws, which differ so widely in shape and appearance, are all made of practically the same chemical material. These are being investigated by the new method.

No matter whether the protein fibers were formed as the result of life processes or whether they were synthesized in the chemical laboratory, X-ray diffraction photographs reveal the twisted fibril as one of the most common structures of protein. Yet it is not quite unique. A few other materials of similar chemical nature vary the pattern by occurring in a shape the scientists describe as a "pleated sheet." These varieties only add zest to the puzzle. The scientists go on eagerly looking for more kinds of tissues to analyze, in such objects as porcupine quills and the tendons of kangaroos' tails.

In England a group of scientists at the University of Leeds, under the direction of Dr. W. T. Astbury, has extended the study from hair to the flagellae that surround bacteria. By whipping back and forth, the flagellae propel those microscopic forms through the liquids in which they live. By studying them light has been shed on the stretching and contraction of many kinds of protein fibers.

While this information on the physical properties of protein fibers is interesting, the California scientists prefer to work on the chemical side of

the problem. They want to know how the protein molecules are built up. They start with the idea of a molecular chain made up of a number of sets of atoms. They imagine this chain twisted so that each set of atoms appears at intervals around the surface of a helix, somewhat like bunches of beads strung on a wire. They make measurements which will describe this spacing. These are in terms of the number of bunches around the cylinder in each repeat of the pattern, the distance along the cylinder that these repeats occur, and the radius of the cylinder or helix.

The measurements from the X-ray photographs of protein material allow scientists to calculate these distances in the molecular chain. Formulas have also been worked out for combinations of helices which coil around each other or intertwine in various directions. If one helix of such a group is taken as the standard, the others may be considered to be twined around it.

With a set of measurements and calculations for some substance, such as the keratin from hair, Dr. Pauling and Dr. Corey can construct an accurate model of the molecule. It is very much like a rope. It combines a left-hand twist of individual strands with a right-hand twist of the whole rope-like fiber.

Chemically simpler nucleic acids have been found to have about 24 molecular groups strung on seven turns of the helix. This helix is twisted like a right-hand screw.

Seven-strand cables are found in some protein structures. In them six spirally twisted fibrils twine around a central helix. Between such cables

there is room for an occasional single twisted strand. There is evidence that these are two different materials occurring together. They can sometimes be separated by chemical treatment.

Understanding such details about the structure of these complex chemical units of living matter is import-

ant. It aids in building up new compounds from theoretical plans. It helps in finding what has gone wrong with natural processes in disease or injury. It is also an exciting puzzle. Every piece that is fitted in adds to the beauty and complexity of the emerging pattern.

On the Back Cover

► FEATHERS are only one of the forms of protein found by Dr. Linus Pauling to have a molecular structure like twisted rope. Keratin is the chemical name of this protein, which occurs also in fur, hair, nails, claws, horn and skin. The feathers in this picture came (left to right) from the Osprey, the Albatross and the Snowy Owl.

Illusive Particle Made in Cosmotron

► ANOTHER of the illusive particles within the heart of matter, known as the neutral V-particle, has been created for the first time artificially in the giant cosmotron atomic accelerator at Brookhaven National Laboratory. The cosmotron was operating at an energy of 2.2 billion electron volts when it yielded two definite examples of these V particles, so-called from the shape of their vapor trails in the experimental chamber which was bombarded with powerful neu-

trons. They were similar to those found in cosmic rays but never before assuredly manufactured by man-made radiation. Only two definite examples of the neutral V particle were found on about 4,000 photographs taken.

This is another step toward understanding the atomic nucleus in which is locked secrets of matter and energy. The experiments were done by Drs. W. B. Fowler, R. P. Shutt, A. M. Thorndike and W. L. Whittemore.

Which of Three H-Bombs Did Soviets Succeed in Making?

Three Hydrogens Possible for Bombs

by WATSON DAVIS

► ASSUMING that Russia does have the hydrogen superbomb (and we must credit Soviet science with capability), the question is what kind of a hydrogen bomb do they have? What kind do we have?

For there are several possible "fusion" bombs that operate by what is called "thermonuclear reactions."

They are all hydrogen bombs, but there are three kinds of hydrogen: 1. The ordinary and plentiful kind. 2. Deuterium, the double weight kind, rare but occurring in nature. 3. Tritium, the triple weight kind that is radioactive and has to be manufactured.

From highly secret tests at Eniwetok, our scientists probably know now which kinds can be used for superbombs. For there is little doubt that we have exploded one or more hydrogen bombs.

Most of those engaging in more or less informed guessing believe that tritium is the superbomb material of choice. Two atoms of tritium (H^3) brought together with sufficient violence would fuse into and form a helium atom (He^4) and give off two neutrons. (Neutrons are the uncharged atomic particles that trigger the atom bomb.) There would be a terrific release of energy due to the fact that mass of the two tritiums is slightly more than that of the helium and the neutrons and that this mass is converted into energy.

But two deuterium atoms similarly thrown together should also fuse, giving in one reaction a tritium atom and an ordinary hydrogen atom, and in an alternate reaction a mass three helium atom and a neutron. Both would release large energy.

There could also be reactions between atoms of deuterium and tritium, which should be violently explosive. Participation of ordinary hydrogen would be likely to slow things down too much.

All the hydrogen bombs presumably would need extremely sudden and high temperatures to be kicked off. A fission bomb of uranium 235 or plutonium (the conventional atomic bomb if anything atomic can be called conventional) is used to trigger a hydrogen bomb. It creates sun-like temperatures, a million degrees or so.

The speed of interaction of the hydrogen material is all important. For the violence of the explosion will throw the material apart and it must do its combining in a few millionths of a second. The hydrogen bomb is cheaper and more practical from a production standpoint if its material is deuterium, or double-weight hydrogen. This isotope of hydrogen is separated from water, in which a small amount occurs. The process is somewhat like the way in which the fissionable uranium, isotope 235, is separated from the most plentiful ura-

mium 238 with which it occurs in the natural deposits. Deuterium can be obtained without use of materials that enter into the production of fission or ordinary A-bombs.

But the production of tritium is a drain on the uranium supply. It must be manufactured, probably from lithium metal, by bombardment with neutrons. The fissioning of uranium, or plutonium made from uranium, is the only practical source of neutrons for this purpose. This would be done in an atomic reactor of the same sort that is used to make plutonium, by bombarding uranium 238 with the neutrons from a slowed-down reaction such as occurs in the atomic fission bomb.

Tritium for hydrogen bombs can be made only at the sacrifice of atomic bomb production and a large sacrifice of total explosive power. It is necessary to forego some of the total punching power to obtain the super-punch of a bomb that is perhaps a thousand times that of the Hiroshima bomb, a superbomb capable of devastating vast territory.

If deuterium can be made to explode, hydrogen bomb production is not dependent upon the uranium supply except to provide the triggering fission bombs.

Tritium is radioactive and half of it disintegrates in about 11 years. Making it and stockpiling for use in the distant future is wasteful because of this natural disintegration.

All of the hydrogens as elements are gases which are unhandy to use, but they can be combined with other elements into solids. Plutonium tritide or plutonium deuteride would give both the fissionable and the fu-

sionable atomic energy elements in the same compound. Perhaps they are packaged in this way for the hydrogen bomb.

A hydrogen bomb would probably be detectable most assuredly by the large amount of radioactive carbon created in the gigantic explosion. The nitrogen in the atmosphere bombarded by neutrons given off by the superbomb would be turned into carbon 14, just as the cosmic rays create continuously this kind of carbon in very small amounts in the upper atmosphere. This radioactive material comes down to near the earth's surface and can be used to date things that contain carbon.

If a hundred or so superbombs were exploded, they might so poison the atmosphere with radioactivity as to affect human life, increasing the cancer incidence. If cobalt were added to the hydrogen bomb with fiendish intent, the radioactive cobalt 60 produced and spread in the air would have the effect of so much deadly radium. Life itself on earth would be jeopardized.

When and if the government tells what has been discovered by the superbomb research and development, we shall be able to form a better judgment as to the hazards of superbombs.

Defense of the civilian population is little changed by a merely bigger bomb. As the bombs become more powerful, the possibility of making peace and keeping out of war with the Soviets becomes more important.

But there is also speculation that the hydrogen bomb can be made without using the older and less powerful

atomic bomb (fission of uranium or plutonium) as a trigger.

Suppose a lower temperature, say a few hundred thousand degrees, would start the conversion to energy of some of the mass of hydrogen atoms (whether the common sort of mass one plus, or the double weight deuterium, or the triple weight tritium). Then the required intense spot of heat might be provided by a fine metallic wire exploded by a shock of electricity.

This possible trigger of the H-bomb was forecast by exploding wire experiments at Mt. Wilson Observatory in the 1920's, when attempts were made to duplicate here on earth the temperatures and the light of the stars.

Such a non-A-bomb trigger might very well break the monopoly that uranium now has on atomic bomb production. Hydrogen is widespread in the world. The ordinary and double sort is in every drop of water. Even less technological nations than the United States and Russia might undertake H-bomb development with relatively limited resources.

For future power for industry, such possible developments may have more interest and promise to the world than for military might and destruction, if war can be avoided. Easier starting of the H-bomb fusion, or conversion of mass into energy, if combined with control of the rate of fusion, would give a great new source

of power for war and peace, unhampered by the scarcity of uranium.

Experiments in 1949 from the Los Alamos AEC Laboratory actually produced power from the fusion of hydrogen atoms on a small scale. Since work on the hydrogen bomb began well over a decade ago, even before the fission atomic bomb was proved practical, some very important and practical developments may very well have been made and remain hidden under the cloak of atomic secrecy.

Such industrial and power applications of converting mass into energy, via the hydrogen fusion reactions, should be more important than the making of bombs. But in the present state of the world a relatively easy and cheap H-bomb would obviously throw more fear and apprehension into our military and political leaders than Russia's possession of the kind of super uranium-triggered H-bomb we have assumed has been exploded.

If the public is given solid scientific facts, of the sort that the famous Smyth report of 1945 gave about the atomic bomb, apprehension bordering upon public panic may be avoided. The heralded Operation Candor may be sufficiently candid.

If the safety of the future must depend upon the behavior of any small group in this compact world of ours, we had better know the worst in order that we may, even this late, build up psychological defenses.

So far the most productive U. S. area for uranium has been the Colorado Plateau.

Higher yielding soybeans account for increase of 20% in soybean production, and 10% more oil.

Germanium Revolutionizes Electronic Circuit Design

More Efficient Transistors

► THE TINY transistor, a five-year-old newcomer to the electronics field, now has two baby brothers.

Transistors are made of the rare metal, germanium, which is worth more than gold when suitably refined for transistor use. The pea-sized devices can amplify radio waves, music and speech and can do many other jobs now done by tubes such as are in radio and television sets.

The newest transistors are "tetrodes" and "pentodes." They differ in appearance from their big brother, the "triode," only in that they have three and four wires, respectively, running from the germanium nugget instead of two. Tetrodes can do the work of two of the older triodes. In some cases a pentode will do the work of three triodes.

This means that someday radio and television sets may be fantastically small partly because transistors themselves are small, and partly because the new transistors will simplify electronic circuits.

Developed by Sylvania Electric Products, Inc., the new transistors may find their first jobs in electronic computers.

The new devices are still in the development stage, as is the older triode transistor. As yet, they cannot be used in critical radar circuits. This is because transistor performance is not standardized. If a transistor goes bad in a critical circuit, another transistor usually cannot be substituted for it

without a modification of the complete circuit.

However, transistors now are being used in some noncritical circuits of hearing aids. Future refinements should make them suitable to take over many of the jobs now done by vacuum tubes.

Crystal Junctions Shown

► THE NEW electronic devices, such as transistors depend upon one part of the germanium conducting electrons while the other part of the crystal does not.

A new way of discovering practically the invisible junction between these different regions was announced in a communication to the British journal, *Nature*, by two scientists of the Associated Electrical Industries, E. Billig and J. J. Dowd.

It is expected to be of use in manufacturing these advanced and useful electronic devices.

The boundary of what are called the *n* region, conducting electrons, and the *p* region, with electrical "holes," can be shown up by electrolytic etching. The junction acts as a rectifier and electricity is forced through the metal so that the *n* or electron region is attacked. This can thus be seen visually.

Miniature Radio and TV

► COMMERCIAL production of Dick Tracy wrist radios some day may be made possible by the tiny electrical wonder, the transistor. But vest-

pocket television sets seem improbable.

Two engineers working for a large electrical-equipment manufacturer recently fabricated an experimental wrist-sized radio using transistors. The radio is one and a half inches long, two inches wide and three-fourths of an inch thick. Its antenna is worn inside the coat.

Another company produced an experimental, transistorized portable television set that you can carry with you to the beach. But considering the complexities of television picture tubes, it seems unlikely that anyone will create a vest-pocket video set in the future.

Although plagued by the "bugs" that usually go along with new things, transistor research rapidly is revealing effective "bug-exterminating" methods.

Transistors, because of their small size, promise to permit great shrinkage in some electronic equipment. Following in the trend toward smallness, manufacturers of electronic circuit parts are turning out baby coils, condensers and resistors.

Electronic experts who design military equipment are keeping sharp eyes focused upon transistors. If the tiny devices can be substituted for some of the regular vacuum tubes, radar sets and gun-aiming devices can be made smaller, lighter, more rugged and perhaps more reliable.

But transistors are finicky temperature-wise. They do not work properly when hot. When mixed with regular vacuum tubes—which produce great heat in confined quarters—transistors frequently fail unless pampered by refrigeration.

Scientists, though, are working at these problems. They are learning to seal transistors hermetically against the damaging effect of high humidity. They are trying to standardize the performance of similar units. Future refinements of the electronic infant promise it a bright future.

Mass Production

► IN SOME ways the tiny transistor has surpassed even the glowing predictions made for it five years ago when its creation was first announced.

Although cantankerous in some ways, transistors are rugged and require little electric power to operate.

They now are being used in Englewood, N.J., in the first installation of customer long distance dialing. Presumably they also are doing secret jobs in military equipment. Hearing aid makers already are putting out transistorized models while radio and television manufacturers are studying them for future applications.

Bell Laboratories report 40 experimental types now are undergoing laboratory tests. Some of the experimental transistors foretell applications of the highest order of usefulness.

Germanium Ingot Process

► INGOTS of precious germanium have been successfully produced by a method that promises to revolutionize the manufacture of transistors.

Transistors are small but rugged chunks of germanium that can be used in radios, television sets, hearing aids and giant electronic "brains." They are valuable because they conserve space and electric power and because they last longer than vacuum tubes under the proper conditions.

As many as 100 wafer-thin layers of specially treated germanium can be

produced in a six-inch ingot by the method developed by Dr. Robert N. Hall of the General Electric Research Laboratory. Only one or two layers can be produced by other methods.

Still in a laboratory stage, the method turns out germanium layers mixed with a trace of gallium. These layers are separated by thicker regions of germanium containing antimony. From the single ingot, several thousand transistors can be produced.

One section of the "gallium-doped" layer in each transistor does the work of the grid in a vacuum tube, Dr. Hall explained. The "antimony-doped" layers take the place of the cathode and plate in a tube.

This "mass" transistor production, when it comes to the commercial stage, is expected to cut transistor cost. At present the revolutionary electronic devices cost more than vacuum tubes.

Aluminum-Antimony Metal

► THE REVOLUTIONARY transistor itself may soon be revolutionized. Newly-developed, low-cost materials, revealed for the first time at a recent meeting of the American Physical Society, may do it. The materials have electrical properties similar to the expensive germanium now used in transistors.

The new materials are compounds of aluminum, gallium and indium with arsenic and antimony. They are now being tested by scientists at Battelle Memorial Institute, Columbus, Ohio, at Bell Telephone Laboratories and at the National Bureau of Standards. They have already been successfully used to change small amounts of alternating current into direct current. To scientists working on the project, this means the material may be suitable for transistors.

Costwise, the compounds are less expensive than hard-to-get germanium. Both aluminum and antimony, for example, sell for less than 50 cents a pound. Germanium costs \$350 a pound.

Scientists speculate that the aluminum-antimony compound may even be better than germanium where high operating temperatures are met. Such conditions often appear in military equipment.

Silicon Metal Available

► SILICON for use as an electric current converter, or transistor, was tried out some seven years ago, but has been nosed out of the race more recently by the rare metal germanium. Now that the Du Pont Company is putting a new plant into operation to produce silicon in its "metallic" form, this common element found everywhere in rocks and sand may again furnish essential parts for electronic apparatus.

Like carbon, silicon can take several different forms. It does not form "diamonds," but it can be either soft and smudgy or hard and metallic. Smudgy silicon corresponds to carbon in lead pencils. Metallic silicon is similar to the hard graphite bricks of carbon used in the atomic piles. The high price of silicon in this form, announced by Du Pont as \$430 per pound, reflects the trickiness of getting the material out pure and in the required state. The price should drop as new uses increase the demand for silicon in electronic circuits. Silicon is closely related chemically to germanium as well as to carbon, and its use as a transistor depends upon the same principles as those that let germanium substitute for bulky electron tubes.

**Stars are Observed
By Radio and Light**

Instruments Watch Matter in Space

➤ CLEARER and faster pictures of the stars can now be made by a new method that combines electronics and photography.

Still in the development stage, the method was devised by Drs. Andre Lallemand and Maurice Duchesne of the Observatory of Paris, France. It gives extremely clear photographs in much shorter times than has previously been possible.

Combining electronics and photography the new instrument presents astronomers with a new, sensitive tool for their study of the heavens, just as the electron microscope greatly aided biologists in their study of cells.

The star's light is focused through a telescope, not as usual on a photographic plate, but on a light-sensitive plate made of glass-covered antimony and cesium. This photoelectric plate gives off electrons when hit by light. On the average, one out of four photons, or units, of light causes the emission of one electron from the plate.

The electrons are then focused and speeded to the target photographic plate by a potential difference of 30,000 volts, in the same manner as in the electron microscope.

When light falls directly on a photographic plate, only about one in 200 of the light units reacts with the emulsion to give an image. The antimony-cesium photoelectric plate thus has a 50 to one advantage over a photographic plate used alone.

Since the photoelectric plate operates only in a high vacuum, it is first placed in an inner airtight container inside the vacuum part of the new instrument, and held off to one side by a magnet until needed. The air is then pumped out, and the star's image is focused on the spot inside the vacuum where the photoelectric plate will be.

After these two steps, the airtight inner container is broken and the plate moved to the telescope focus with the aid of two magnets. When the star's light hits the plate, the electrons are given off and speeded on their way to the photographic plate giving about fifty times the efficiency of the star's light used alone.

On an electronic photograph taken with an exposure of five seconds, Drs. Lallemand and Duchesne have been able to resolve the fourth star of a grouping in the constellation of Orion, the hunter, although a sensitive photographic plate exposed for three minutes in the usual fashion shows only three of the four stars.

Ultrasensitive Photometer

➤ A NEW ultrasensitive photometer that literally counts individual photons, or packets, of light was described to the American Astronomical Society meeting in Boulder, Colo.

Use of the photometer has already doubled the volume of space that Mount Palomar's giant 200-inch telescope can view. It can now search out

stars of magnitude 23, hundreds of millions times fainter than Sirius, the brightest star we see.

The device is being used to measure the very faint light received from galaxies far distant from our own Milky Way. Although it has already increased the seeing power of the world's largest telescope, eventually, Dr. W. A. Baum of Mount Wilson and Palomar Observatories foresees, it may even further enlarge the amount of space the telescope can penetrate.

The photometer is used to measure, simultaneously, the luminosities and diameters of galaxies lying beyond those in our own neighborhood of the universe. Astronomers have been continually devising new techniques for measuring the very faint light received from such objects, and the ultrasensitive photometer is their most recent development.

The combined results of the luminosity and diameter measurements are fitted to Einstein's general relativity equations. This enables Dr. Baum and his associates to separate those differences that are due to the distance of the galaxy and its motion away from us from those that are caused by obscuring clouds and the life history of the object.

Preliminary results seem to show that the change undergone by such objects as they go through their life cycles may materially alter the present ideas of how far away these galaxies actually are. These distances until now have been based on luminosity alone, without taking the evolutionary change into account.

The photometer, for the first time,

makes it possible for astronomers to take photoelectric measurements with the 200-inch telescope down to the limit of photographic plate sensitivity. Thus Dr. Baum and his associates were able to get the first real measure of the giant's photographic range, which turned out to be half a magnitude beyond previous estimates.

The photometer, Dr. Baum explained, can actually detect objects considerably beyond the photographic limits. Experiments in the subphotographic range, however, should wait until possibilities of electronic image receivers have been more thoroughly investigated.

Meteor Streams and Comets

➤ TWO MORE meteor streams have now been linked with periodic comets, Dr. Fred L. Whipple of Harvard College Observatory reported to the astronomers meeting at Boulder, Colo.

All of the recognized visual and radar meteor streams fall in the class of cometary origin, Dr. Whipple said. Some astronomers have suggested that perhaps the asteroids, or minor planets, might be responsible for some meteor streams.

When the billions of tiny particles that are part of meteor streams crash into our atmosphere, many of them cause the brief streaks of light known as "shooting stars." About half of the meteors caught photographically are associated with a comet, Dr. Whipple said, and about half are random, or sporadic.

The two periodic comets that have now been linked up with meteor streams are Comet Tuttle 1926-IV and Comet Mellish 1917-I. Comet Lowe 1913-I probably also has an

associated meteor stream, Dr. Whipple believes.

The meteors were photographed by cameras equipped with rotating shutters and located at two separated stations. The shutters make periodic breaks in the meteor's trail to reveal how much it is slowed down by the atmosphere. From this its speed before hitting our atmosphere can be calculated.

Star Growth Watched

► THE GROWTH of dwarf stars by building up from dust particles in surrounding clouds can be watched by the spectroscopic "eyes" of giant telescopes.

The changes may, however, take months or years for astronomers to spot, Dr. Alfred H. Joy of the Mount Wilson and Palomar Observatories in California told the meeting in his address as retiring president.

Variations in the amount of light received from some dwarf stars in our Milky Way galaxy are apparently caused, Dr. Joy said, by contact of the stars with interstellar dust clouds. Because light from dwarf stars is very feeble, it is difficult to spot any except the nearest ones.

Another type of light variation, so far found only in nine stars, lasts for only a few minutes. In these stars, hot flares, covering only one or two percent of the surface, burst forth to increase the total brightness many times, but only for a very brief period. Hot flares of a similar type are frequently found near sunspots on the solar disk.

The spectrum, or rainbow of spread-out light, for such flares, Dr. Joy reported, shows temperatures as

high as 10,000 degrees absolute. They are found in the small, red dwarf stars whose temperatures are cooler than that of the sun.

Previously, all variable stars had been considered to be stars of high luminosity whose light changes were accompanied by vast, but fairly regular pulsating movements and moderate changes in the temperature of the outer atmosphere.

Now, Dr. Joy said, it is certain that some of these variable stars are dwarfs, and that their light variations result from explosive outbursts covering limited areas of the star's surface.

A third type of dwarf variable may be two stars close together. One of them may have a shell that either expands or rotates at 450 miles per second, the other an atmosphere slightly cooler than that of the sun. At irregular intervals, the hot source blows up, increasing its intensity a hundred times.

Other types of dwarf variables include the novae, some of which can explode more than once. When they burst out, their brightness increases several thousand times. In the dwarf binaries, another type of variable, dark areas and bright prominences, similar to those of our sun, have been found.

Radio messages that tell of the internal and external activities of our nearest galactic neighbors, a hundred million billion miles away, were reported to the American Astronomical Society meeting.

The volumes of the Clouds of Magellan are larger and their motions more turbulent when measured by radio waves than by ordinary light,

Drs. Frank J. Kerr and J. V. Hindman of the Radiophysics Laboratory, Sydney, Australia, informed the astronomers in a paper read at the meeting by Bernard Y. Mills, also of the Laboratory.

The astronomers also learned that the Magellanic Clouds are farther away than previously thought. Dr. Harlow Shapley of Harvard College Observatory communicated the new value of 175,000 light years for their distance, an increase of 25,000 light years from that reported to the astronomers in December, 1952. (A light year is the distance traveled by light at 186,000 miles per second in a year, or nearly six million million miles.)

Dr. Shapley's new distance figure is based on measurements of stars in globular clusters that are inside the Magellanic Clouds, visible only from the Southern Hemisphere.

The Australian scientists made their new radio wave studies of the distribution, abundance and motion of hydrogen gas in both the Large and Small Magellanic Clouds with techniques developed this past year at the Harvard, Leiden and Sydney Observatories. The new techniques are for the discovery and measurement of the peculiar radiations emitted by the neutral hydrogen atoms that are in the spaces between the stars. The wavelength of this radiation is about eight inches, but the exact wavelength depends on the motions of the clouds of hydrogen gas and is a measure of that motion.

If the gas is approaching, the wavelength is shorter; if it is receding, the wavelength is longer. Drs. Kerr and

Hindman found various wavelength shifts in different parts of the Clouds. They conclude, therefore, that at least the Large Cloud is turbulent inside, as its irregular structure would suggest.

They also found that the Clouds are rotating around a common center of gravity, with the Large Cloud at this time receding, the Small Cloud approaching, at the relative rate of about 30 miles a second. The Clouds are traveling through space together, as they revolve around each other, at a speed of more than 300 miles a second.

In all this new and important work on the anatomy of the nearby galaxies, as revealed by the measures of neutral hydrogen gas, it is assumed that as the hydrogen gas goes, so goes the whole galaxy of hundreds of millions of stars.

Drs. Kerr and Hindman discovered that the hydrogen gas of the Clouds is spread out in space more widely than are the stars. The volumes of the Magellanic Clouds as indicated by the radio signals are probably twice the dimensions that are shown by optical means, that is, by the blue light signals, or photographs, of the component stars.

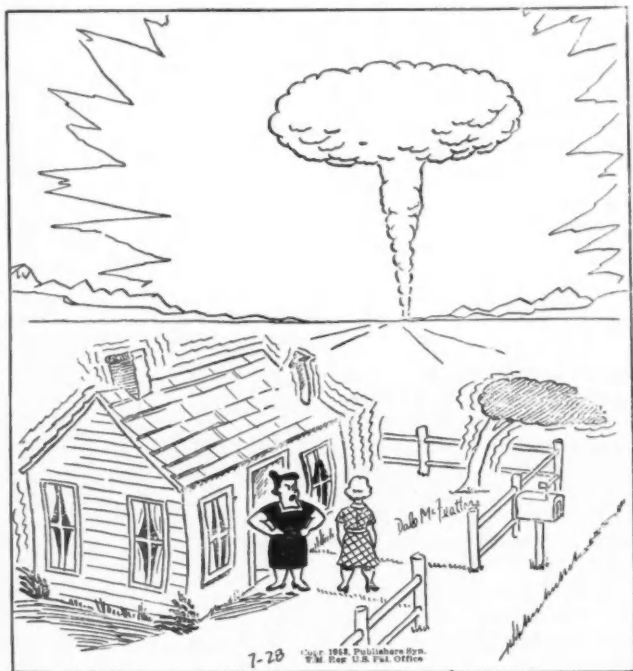
The optical work has been done by Harvard College Observatory astronomers, who have been the chief investigators of the Clouds for the last 50 years.

The Australian scientists estimate the interstellar hydrogen constitutes about 10% of the total material of the Small Cloud, and three percent of the Large Cloud.

Their work is still in its preliminary

stages, but their researches are considered by astronomers to be among the most important contributions in recent years to our knowledge of the structure of the galaxies that lie outside our own.

The method of employing the radio technique to show the neutral hydrogen of interstellar space has been used by Dutch astronomers during the past year to map out the spiral structure of our own galaxy.



► "I KNEW IT! It always happens when I put a cake in the oven!"

Future Source of High Protein Food

Algae May Feed Starving World

► FUTURE POPULATIONS of the world will be kept from starving by production of improved or "educated" algae, related to the green scum on ponds. These one-celled plants can provide food high in protein which is in shortest world supply. Algae can utilize sunshine and air more efficiently than any living or mechanical process.

This is forecast in the first comprehensive report on a far-flung investigation on algal culture by the Carnegie Institution of Washington.

The need of the world for additional sources of high-protein food is so great, especially in over-populated areas, that serious effort in tracking down every promising lead is certainly warranted, Dr. Vannevar Bush, president of the Carnegie Institution, explained.

Such great advances in technology have already come from the coupling of engineering with biology that it seems inevitable that the production of food, at least in certain areas, will eventually be carried out by process industries. The large-scale culture of algae may well become the first of them. In regions of the world where population is especially dense, and fertile land is limited, it is entirely possible that process-industry methods of producing food may furnish a respite from the threat of famine and so contribute toward more salutary conditions for civilized living. If algae

culture can serve such a purpose, it is well worth development for that reason alone.

It is hoped that such a development may take the form ultimately of a multitude of individually owned, relatively small establishments, combining the culture of algae perhaps with utilization of the product for animal feeding on the spot. The new industry that would result would thus enter into our economic life in such a manner as not to produce disruption, but rather to strengthen individual enterprise.

The first large-scale use of cultivated algae as human food took place in Venezuela a decade ago when lepers were fed successfully soup made from algae, the report reveals for the first time.

For centuries oriental peoples have eaten seaweeds, which are large-sized algae, and some are considered a delicacy. Scientists have been confident that some kinds of microscopic algae will be suitable and acceptable as human food.

From two pilot-plant productions of algae, one in Cambridge, Mass., and the other in Japan, Chlorella algae powder has been sampled for taste and palatability. American experiments showed that Chlorella alone is too strong in flavor for one to enjoy eating large quantities of it but it is pleasing as a garnish. It can be added up to 15% to a chicken-base

soup successfully. Japanese reported that their product tastes like dried seaweed or powdered green tea, both popular in Japan.

Algae are expected to become an industrial raw material for protein, fat, vitamin or even antibiotic content. Moreover, experiments are in progress to find strains of algae that will have special qualities for food and other uses. There are about 17,000 different species.

The primitive character of the cells of microscopic algae is such that they are practically all food, without the waste present in stems, roots and leaves of higher plants. Dried cells are often more than half protein, more than in any higher plants. Algae can be made to produce a continuous

crop regardless of weather and time of year.

In the larger scale tests, algae have been grown in plastic tubing exposed to sunlight, with nitrogen fertilizer and concentrated carbon dioxide supplied. Full, continuous sunlight does not produce the most efficient results, for each green alga cell must have intermittent light and can utilize in photosynthesis only a limited amount of light energy at a time. Turbulent flow of the growing culture will be tried to produce the best conditions.

Plans are being made, it is stated in the report, which is edited by John S. Burlew, to build a demonstration plant covering about an acre when some of the problems discovered in the experimentation so far have been solved.

Fast-Flipping Switch for "Brain"

➤ A FAST-FLIPPING silicon switch has been developed that keeps electronic "brains" from getting amnesia.

Officially called "silicon alloy junction diodes" by Bell Telephone Laboratories engineers who developed them, the switches permit electricity to flow only in one direction.

If the current tries to move in the opposite direction, the match-head-sized devices throw up great resistance. Measurements show that current leaking backward through ordinary vacuum tube rectifiers can be a thousand times greater than the amount that can get past the sturdy resistance of the silicon alloy diodes.

By passing a tiny charge of electricity to the plates of a condenser, the new switch permits complex electronic "brains" to store one bit of information. By keeping the charge from leaking off the condenser, the diodes prevent the brains from forgetting.

An outgrowth of transistor research, the junction diode works thousands of times faster than its best mechanical counterparts. It requires no filament, therefore needs no warm-up time before working properly. It can withstand high temperatures. Engineers predict its lifespan "should be almost unlimited."

Steel one-tenth the thickness of a human hair has been developed for use in a secret electronic device.

**When Summer Ends
Brilliant Colors Are Unmasked**

Leaves Brighten Autumn

► THE BRIGHT colors of autumn leaves which everyone admires have actually been there all summer. Every leaf, no matter how brilliantly green during the verdant growing season, has within it the bright colors that appear when the shorter, cooler days bring the changes to autumn foliage.

One of the changes that occurs in the leaves when autumn comes is chemical breakdown of the chlorophyll. This material is involved in capturing the summer sunlight. It uses its energy to transform the carbon dioxide of the air and the water from the soil into food. The sugar starch and protein thus make green growing things luscious food for animals.

At the coming of autumn a chemical transformation takes place in the leaf as the tree puts the liquid foodstuffs of its foliage back into its limbs and trunk. The green matter, the all important chlorophyll, breaks down and becomes colorless. The bright leaf colors which have been hidden in the growing season become unmasked and shine forth.

Two general classes of chemical compounds are responsible for the coloration of the dying leaves. These are carotinoids, which are responsible for the yellows, and anthocyanins, which give the reds and the purples.

The carotinoid pigments present in all the leaves do not have a chance to show themselves when, during the summer, the chlorophyll, with its abundant green coloring, is dominant.

Chlorophyll is always being both formed and destroyed in leaves, but in autumn destruction goes on faster than formation, finally reducing it to a low point which permits the yellow carotinoids to be seen. If no other masking pigment is present, such leaves become pure yellow or orange, like tuliptree, willow and sassafras.

The other class of pigments, the anthocyanins, are dissolved in the cell sap. With the exception of a few purple-leaved or bronze-leaved plants, these pigments are also concealed by the more abundant chlorophyll, and show themselves only when it has been sufficiently broken down. At the same time, certain changes in the carbohydrate content of the leaves may cause an actual increase in the amount of the anthocyanins present. Thus we get the strong reds and purples of sumac, blackberry, sweet-gum, the oaks, etc.

Trees like maples, which sometimes show a gorgeous mottling of yellows and reds, may have local patches of anthocyanins masking out the carotinoid ground-color.

Combinations of the purples, purple-reds, oranges and true reds make all the varied colors we find in autumn leaves—and in the skins of autumn fruits as well. Leaves of a clear yellow, such as you sometimes find on hard maples, have no purple pigment in the sap. Leaves of a strong, deep wine-red are colored by a combination of purple sap-pigment and red

carotin in the cells. The changes that may be rung on this color-chime are literally endless.

Even more remarkable than the wonder of leaf coloring, though much less conspicuous, is the provision made by the leaves for their falling off. They do not just snap off and drop, as a dead twig might. That would leave the tree covered with thousands of tiny, open wounds through which bacteria and fungus spores might enter, to cause disease and decay.

At the point where the leaf-stem is later to detach itself from the twig, a double layer of specialized, corky cells forms, finally cutting off the sap flow to and from the leaf. When it is complete, the union between the two layers becomes dried out and weak, and finally a little puff of wind finishes the job, letting the dead leaf drift down to earth.

Botanists have given this double layer a special name, "absciss layer." But that is only Latin for cut-off layer, and that is exactly what its function is. The tree or shrub is thus able to bandage its wounds before they actually exist. That is a trick that surgeons and first-aiders would give a good deal to be able to do for humans.

Poetically there may be sadness because leaves must die, fall from the trees and molder in the earth. Such a view does not fit in with the cycle of life in forest and field. The dead leaves must return to the soil and substances which the soil originally gave them, if the earth is to remain fruitful and new crops of leaves are to be produced in succeeding springs.

Leaves, despite their beauty and brilliance, when they fall to the ground become a nuisance. The brisk autumn chill may be pleasantly warmed by bonfires of leaves but this mode of leaf disposal is frowned upon by firemen, health officials and good gardeners. There is a real danger of setting off forest or field fires when leaves are carelessly burned. A little smoke may give a spicy odor to the autumn air but too often leaf-burning pollutes the atmosphere with smoke and smog. The real crime of burning leaves is that they cannot then be used in the green growth of future years.

Trees are the reincarnations of their own dead forebears. Without the decaying leaves of yesteryear and the moldering logs and stumps of the last generation there would not be life enough in the soil to sustain the new trunks and branches that grow out of it.

The mass of dead but life-giving material is called humus. The enriching processes of the forest soils are actually different from those of garden and field. Bacteria largely attend in open spaces to the task of returning dead things to the dust whence they came, but in the forest the work is done primarily by fungi. A large share is done by the higher fungi, the large showy plants that we call mushrooms, which are sometimes edible and sometimes poisonous. Bacteria do play a small part, and insects, millepedes, worms and microscopic forms do their share. The dark world of the humus upon the floor of the forest is really a seething complex of life.

For The Home Lab

Bismuth

by BURTON L. HAWK

► BISMUTH is one of those quiet and unassuming elements about which we hear little. It does not have any spectacular properties or exciting history. It rarely makes the headlines and performs its duties without fanfare.

The metal is used chiefly as a component of low-melting alloys which are important in automatic sprinkling systems for fire control. The compounds of bismuth are used in pharmaceutical preparations for upset stomach and ulcers and in patent medicines such as "Pepto-Bismal" and "Bisma-Rex." Certain compounds have also been used in the treatment of syphilis.

Bismuth has been known for centuries, but the early alchemists confused it with lead and tin, probably because of its low melting point. It was not until 1737 that the French chemist Hellot recognized bismuth as an individual metal. His findings were confirmed by Geoffroy in 1753 who described the metal and its properties.

Bismuth is not plentiful. It is found most abundantly as the free element in the United States, Canada, Mexico, Peru and Spain. A smaller portion is found in the form of the oxide, $\text{Bi}_2\text{O}_3 \cdot \text{H}_2\text{O}$, *bismite*, and of the sulfide, Bi_2S_3 , *bismuthenite*.

The metal is reddish-white with a bright metallic luster. It is hard and brittle. It melts at 269 degrees, which is lower than lead but higher than

tin. The molten metal expands on cooling.

We discussed low-melting alloys in a previous article of this series (see "Alloys" — CHEMISTRY December 1950). However, for convenience we will repeat the composition of the familiar Wood's Metal. It is made by melting together 4 parts of bismuth, 2 parts of lead, 1 part of tin and 1 part of cadmium. This alloy melts at 71 deg., or below the boiling point of water. It is interesting to heat a piece of the metal in a test tube of water and see it melt before the water starts to boil.

You can melt bismuth alone quite easily by placing a few small pieces in a spoon and heating over a Bunsen burner flame. At a bright red heat (if you can get it that hot) the metal will burn with a bluish flame and the oxide, Bi_2O_3 , is obtained.

Compounds

Bismuth dissolves slowly in hot concentrated hydrochloric acid and sulfuric acid, but quite readily in nitric acid. Therefore, we will prepare bismuth nitrate as our starting point. Dissolve several small pieces of bismuth in 25 cc. of dilute nitric acid. The resultant light yellow-colored solution is bismuth nitrate, $\text{Bi}(\text{NO}_3)_3$. Bismuth salts hydrolyze readily forming basic salts known as "sub" compounds. Pour 5 cc. of the bismuth nitrate just prepared into 20

cc. of water. A miniature "snow-storm" of white crystals is formed which rapidly settles to the bottom of the vessel. This is bismuth *sub*nitrate, which is insoluble in water. It has been used for years in the preparation of face powders. There is a possibility that it can form nitric acid by hydrolysis with perspiration; therefore, it is not the best choice for this use. It appears that rubbing the face with nitric acid is not to be recommended.

Add 5 cc. of your bismuth nitrate solution to 10 cc. of dilute sodium hydroxide solution. The heavy white precipitate is bismuth hydroxide, $\text{Bi}(\text{OH})_3$. Filter it off and scrape into a dry evaporating dish. Heat gently at first and gradually increase the heat until the white powder turns to a brownish-red color. It will pass through various shades of yellow before reaching this state. When you cease heating, the brownish-red powder will again turn yellow. This is bismuth trioxide, Bi_2O_3 .

Add another 5 cc. portion of bismuth nitrate to a solution of potassium chromate. The bright orange-yellow chromate of bismuth is formed.

Bismuth iodide behaves rather strangely. Prepare it by adding 5 cc. of bismuth nitrate solution to an equal quantity of dilute potassium iodide solution. A dark brown precipitate results. Now add an additional quantity of moderately concentrated potas-

sium iodide solution. The precipitate dissolves to form a clear golden orange liquid. This liquid is known as "Dragendorff's Reagent" and is used as a test to determine the presence of alkaloids. Now if you will pour this clear liquid into a beaker of water, it will precipitate out again.

Other compounds may be prepared if you desire. For example, the trioxide, as obtained above, may be dissolved in hydrochloric acid to obtain bismuth chloride or in sulfuric acid to obtain the sulfate. If water is added to the solutions, the basic salts (subchloride and subsulfate) are formed. The subchloride decomposes immediately to form the oxychloride, BiOCl . This compound is known as "pearl white" and is used as a pigment.

When bismuth is fused with sulfur, the sulfide, Bi_2S_3 , is obtained. This compound is not soluble in yellow ammonium sulfide, which affords a method of separating it from compounds of arsenic and antimony. If bismuth trioxide is fused with potassium hydroxide, the brown potassium bismuthate, KBiO_3 , is formed. This compound is hydrolyzed by water precipitating bismuth pentoxide, Bi_2O_5 .

Bismuth will displace silver from its salts. Drop a piece of bismuth in a solution of silver nitrate. You will soon observe the crystals of silver "growing" on the bismuth.

Thus we have bismuth—useful in the control of fire and indigestion!

Sulfamic acid is a basic ingredient in a new non-caloric drug that is 30 times sweeter than sugar.

America faces a shortage of 50,000 graduate engineers and 20,000 scientists.

Nylon nets, used in commercial fishing, can be stored away while still wet because they do not rot.

**Building One's Own Exhibit
Brings Mastery of the Subject**

Teen Age Scientists

► THE WAY to learn is by doing, and the way to show that you know is to teach somebody else. Young people who have already found a hobby interest in science find that they learn a great deal more about their projects when they plan their Science Fair exhibits. The good exhibit teaches the

spectator, at first glance, the most interesting point that its builder wanted him to learn. And it intrigues his interest to study the rest of the exhibit in greater detail.

The student who wants to build his own exhibit needs to think out carefully what it is that he is trying

► THIS LIGHTNING generator, built by William Alwine, Jr. of Audubon, N. J., is designed to show the principle of operation of the large surge-type lightning generators. This apparatus, with its wire cage enclosing six 20,000-volt condensers and auxilliary equipment, was shown at the third National Science Fair held that year in Washington, D. C.

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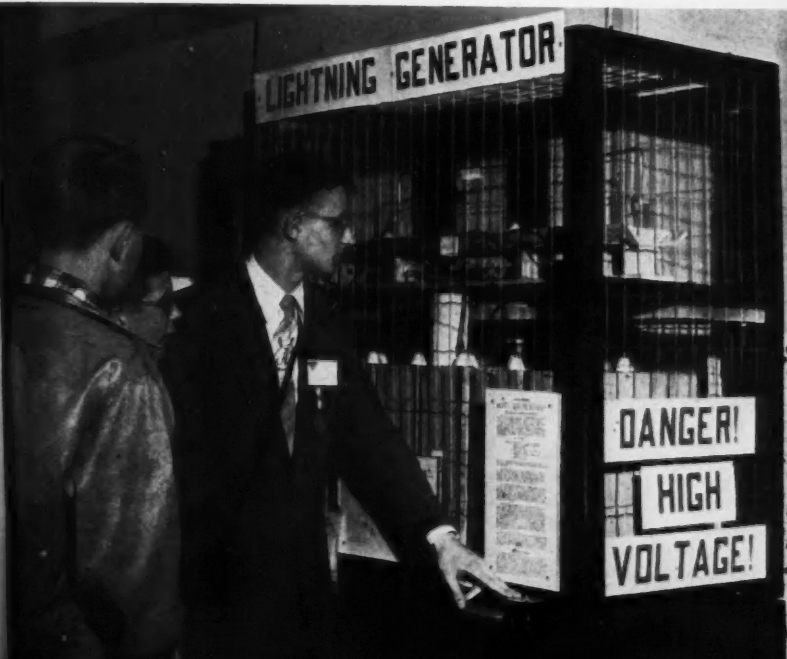
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➤ THE IMPORTANCE of the honeybee and its honey and beeswax was the theme of Patricia Ann Kirchoffner of Devils Lake, North Dakota, when she built her exhibit. It was shown at the fourth National Science Fair which was held at Oak Ridge, Tenn. Live bees at work formed part of the exhibit.

to tell his audience. Too much detail cannot be seen and read easily by spectators as they pass by. Spectacular showmanship attracts the crowds, but counts for less among the scientists who judge the exhibits on the basis of what the student knows and how well he can explain it to those outside his special field.

Boys and girls who are seniors in high schools all over the country are now working on their research reports which are part of their entries in the Thirteenth Annual Science Talent Search. Winners bring to Washington

with them exhibits of the material they worked on for their projects.

Students in the junior and senior high schools are also working on projects to be shown at the Science Fairs their Science Clubs are planning for next spring. Regional Science Fairs are being sponsored by universities, by industry representatives and by community-minded newspapers. More than forty of these have already spoken for space for their winners' exhibits at the Fifth National Science Fair. This will be held in May 1954, at Purdue University, Lafayette, Ind.

Physiological Effect
Of Selenium on Plants

Selenium Compounds

by SHELDON L. GLASHOW, 9th S.T.S.

► I HAVE selected for my scientific project a subject of great interest to me and upon which I have done considerable work, namely, a study of the compounds of selenium and their physiological effect upon plants.

The first part of my work deals with the chemistry of selenium. Space

restricting, I shall limit myself to a description of the methods I have used in the preparation of certain compounds of selenium. I was able to purchase suitable quantities of the crude element at a reasonable price from a chemical house.¹ This was purified by dissolving in nitric acid, forming selenious acid, and precipitating the selenium with sulfur diox-

► SELENIUM compounds and their effect on plants grown in soil containing them was the subject of Sheldon L. Glashow's project in the ninth Science Talent Search. His exhibit contained samples of the chemicals he worked with. Sheldon graduated from the Bronx High School of Science, New York City.

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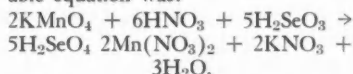
CHEMISTRY



ide in the presence of hydrochloric acid.²

Since, in the latter part of my work, I would require sodium selenite and sodium selenate, I first proceeded to prepare these. The selenite was easily prepared from selenious acid, obtained by dissolving the purified selenium in nitric acid. The manufacture of sodium selenate, however, did not prove so simple. The recommended³ procedure is to react silver selenite with bromine. I attempted this, but in addition to being costly, it was very inefficient with the small quantities I used. I decided to employ a different approach. It was suggested⁴ that chlorine or potassium permanganate could be used in the oxidation of selenious acid. I chose potassium permanganate for its greater ease in

handling. To a solution of selenious acid in nitric acid, I added the equivalent quantity of potassium permanganate. Upon heating, the reaction proceeded to completion. The probable equation was:



After precipitating the manganese as the hydroxide, I added the required quantity of sodium hydroxide and evaporated the solution to dryness. (The presence of the potassium nitrate was not objectionable, as long as its percentage content was known, since the sodium selenate was to be used in plant nutrient solutions requiring the salt). The resulting substance contained 60.9% sodium selenate and 39.1% potassium nitrate.

Chart 1. Composition of Solutions

Solution 1. Control

Primary potassium phosphate	2.3 g/liter
Calcium nitrate	8.0 "
Magnesium sulfate	4.2 "
Trace solution	19.5 cc/liter
Ferric chloride sol. M/10	10 "

Solution 2. Sulfurless

Primary potassium phosphate	2.3 g/liter
Calcium nitrate	8.0 "
Magnesium nitrate	.8 "
Trace solution	19.5 cc/liter
Ferric chloride sol. M/10	10 "

Solution 3. Sodium Selenate

Primary potassium phosphate	2.3 g/liter
Calcium nitrate	8.0 "
Magnesium nitrate	.8 "

Sodium selenate*	6.5 g/liter
Trace solution	19.5 cc/liter
Ferric chloride sol. M/10	10 "

*Actually 10.1 g of the selenate-potassium nitrate mix.

Solution 4. Sodium Selenite

Primary potassium phosphate	2.3 g/liter
Calcium nitrate	8.0 "
Magnesium nitrate	.8 "
Sodium selenite	5.9 "
Trace solution	19.5 cc/liter
Ferric chloride sol. M/10	10 "

Trace Solution

Cupric chloride	.20 g
Manganese nitrate	.25 "
Zinc chloride	.20 "
Boric acid	.40 "
Water	250 cc

Chart 2a. Effect of Selenium upon Growing Plants

<i>Solution</i>	<i>% Germ.</i>	<i>2 wk. growth</i>	<i>3 wk. growth</i>	<i>4 wk. growth</i>
1. Control	92%	1½" tall	2½" tall	Experiments discontinued
Normal Sulfur No Selenium		Healthy plants	Healthy plants	
2. No Sulfur No Selenium	90%	1½" tall Healthy plants	2" tall Symptoms of sulfur deficiency, stiff stems, pale green leaves, long thin roots	
3. No Sulfur Sodium Selenate (Equiv. to S in 1.)	74%	¾" tall Deformed structure, roots discolored	All plants dead or dying Roots completely destroyed	
4. No Sulfur Sodium Selenite (Equiv. to S in 1.)	76%	¾" tall Deformed structure, roots discolored	All plants dead or dying Roots completely destroyed	

Note: Plants used were tomatoes.

I now proceeded to prepare the chlorine compounds of selenium; selenium monochloride (Se_2Cl_2), selenium tetrachloride (SeCl_4), and selenium oxychloride (SeOCl_2). Using the method suggested by Lehner,⁵ elemental selenium was suspended in carbon tetrachloride. A rapid stream of dry chlorine gas was sent through the liquid. The whole of the selenium dissolved, yielding a red solution of selenium monochloride. Attempts to separate the substance failed, since it (the selenium monochloride) proved to be quite unstable, tending to de-

compose into its elements. Upon further addition of chlorine I obtained a precipitate of pearly white selenium tetrachloride. Removing part of this for further study at a later time, I next attempted to make selenium oxychloride. Although partial hydrolysis of the tetrachloride suggested a possible method, I found that some amount of complete hydrolysis inevitably took place, forming unwanted selenious acid. Choosing an alternative method, I reacted the tetrachloride with selenium dioxide in carbon tetrachloride forming, by addition,

Chart 2b. Effect of Selenium upon Growing Plants

<i>Solution</i>	<i>% Germ.</i>	<i>2 wk. growth</i>	<i>3 wk. growth</i>	<i>4 wk. growth</i>
1. Control Normal Sulfur No Selenium	90%	1½" tall Healthy plants	2½" tall Healthy plants	5" tall Healthy plants
2. No Sulfur No Selenium	92%	1½" tall Healthy plants	2" tall Symptoms of sul- fur deficiency, pale green leaves, long thin roots	3" tall Same symptoms, more pronounced
3. No Sulfur Sodium Selenate (½ equiv. to S in 1.)	90%	1½" tall Some discolora- tion of root tips	2½" tall Some discolora- tion of root tips	4½" tall Discoloration still present but plants have healthy ap- pearance
4. No Sulfur Sodium Selenite (½ equiv. to S in 1.)	92%	1½" tall Some discolora- tion of root tips	2" tall Some discolora- tion and damage to root tips	3½" tall Discoloration still present but plants have healthy ap- pearance

selenium oxychloride. The carbon tetrachloride was evaporated off under reduced pressure yielding a reasonably pure sample of the substance. I am, at present, using the oxychloride in an as yet unsuccessful synthesis of selenium nitride, SeN_4 . In the future, I plan to continue this line of work, the preparation and study of the inorganic compounds of selenium.

The second part of my project deals with the effect of selenium upon plant tissues. In South Dakota and its neighboring states, certain plants known as converter plants, generally of the Milk Vetch family, absorb selenium from the soil in large

quantities. Although the soil content of selenium in affected areas is only about 2.5 p.p.m., the converter plants, upon analysis, are seen to contain from 45 p.p.m. to 1610 p.p.m., depending upon the species. Exceptional cases have been known to contain upwards of 9000 p.p.m. selenium. If eaten by livestock, these plants can maim and even kill them. In fact, merely 2.4 lb. of the plant *Astragalus racemosus* will cause the death of a thousand pound animal in twenty-four hours.⁶⁻⁷⁻⁸ This condition is the so-called "Alkali Disease."⁹ Although the effect of selenium upon animals has been exhaustively studied, little

work has been done on its effect upon the living plant system.¹⁰

The purpose of the set of experiments that I shall describe is to determine the effect upon the growth of tomato plants¹¹ when grown hydroponically in solutions in which selenium has been substituted for sulfur. There are, obviously, four possibilities:

1. The plants will show signs of sulfur deficiency and will suffer toxic effects from the selenium.
2. The plants will show signs of sulfur deficiency but will not be adversely affected by the selenium.
3. The plants will use the selenium in place of sulfur, but will show severe toxic effects.
4. The plants will use the selenium in place of sulfur without showing severe toxic effects.

Four nutrient solutions were prepared (see chart 1) differing in the following respects:

1. Control solution¹² containing normal sulfur requirement, but no selenium.
2. Same as solution (1) but containing no sulfur.
3. Same as solution (1) but having sulfur replaced by an equivalent quantity of selenium, as sodium selenate.
4. Same as solution (1) but having sulfur replaced by an equivalent quantity of selenium, as sodium selenite.

Fifty tomato seeds were planted under blotters moistened with each solution (total of 200 seeds.) After one week, the uppermost blotters were removed and the plants were exposed to sunlight daily. The number of seeds germinated and the quality of the seedlings were recorded (see chart 2a), but after a total of two weeks growth, it was apparent that the experiment could no longer continue, since the reduction of the selenium compounds in the plants grown in solutions (3) and (4) had destroyed the growing tips of the roots. To remedy this, the selenium content of these solutions was cut in half. A new set of seeds were planted as before. The results of this set of experiments were successful and appear on chart 2b. They seem to indicate (The results are far from definitive) that possibility (4) is true, i.e. the plants use the selenium in place of sulfur, suffering only minor toxic effects. As the chart shows, sodium selenate is somewhat less toxic than the selenite. This agrees with the findings of Levine¹³ in his treatment of the animal system. Under microscopic examination, I found that some of the selenium had been precipitated extracellularly throughout the plants.¹⁴ However, upon analysis,¹⁵ the plants were found to contain comparatively large quantities of unreduced selenium, further evidence that some of the element had been employed constructively.

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- ⁹Lehner, Victor, *Journal American Chemical Society*, v. 42, pp. 2498-2500, 1920
- ¹⁰South Dakota State Planning Board, 1937 (Proceedings)
- ¹¹South Dakota State Planning Board, 1938 (Proceedings)
- ¹²Miller, J. T. and Byers, H. G., *Journal of Industrial and Engineering Chemistry*, v. 13, pp. 456, 1935
- ¹³Moxin, Alvin L., *Technical Bulletin No. 2*, South Dakota Experimental Station, 1939
- ¹⁴Doty, M. F., N.Y. Public Library Reference Bulletin, v. 30 pp. 1440-1448, 1926 (Bibliography of Selenium, 1817-1925)
- ¹⁵Tomato plants were chosen for their sensitivity to environmental changes.
- ¹⁶Connors, "Chemical Gardening," pp. 195-196, 1940
- ¹⁷Levine, Victor, N.Y. Academy of Sciences, *annals*, v. 26, pp. 385-394, 1934
- ¹⁸This signifies that some selenium had reacted toxically with the plant, causing oxidation of the tissues.
- ¹⁹The method I used was far from quantitative. The plants were ground into pulp, which was digested in water overnight. The resulting liquid was filtered and evaporated to a small bulk. To the filtrate (which contained the unreduced portion of the selenium), I added a small quantity of hydrochloric acid, then passed through sulfur dioxide gas, which reduced the selenium, whose presence was indicated by a red color. I was able to determine that the percentage of selenium in the plants was much greater than that in the nutrient solutions (3) and (4).

Blue Dye Shows Egg in Noodles

► HOW MUCH egg in noodles, if any? A blue dye can tell. The U. S. Army's Quartermaster Subsistence Testing Laboratory, Chicago, grinds up samples of the noodles it buys for feeding the fighting forces, adds the dye and then determines the depth of the blueness by a colorimeter. Because eggs have a fatty, phosphorus-containing product which is stained by the dye, the bluer the noodles, the more egg.

Egg noodles have to contain 5.5% egg yolk solids to meet Army specifications. The new blueness test is not yet official, but is used for screening purposes.

The new test is reported to the *Journal of Agricultural and Food Chemistry* by John E. DesPaul, Albert Weinstock and Charles H. Coleman.

Drug Over Half Gold

► A DRUG containing 54% gold can treat rheumatoid arthritis effectively, especially in the early stages of the disease, a New York physician, Dr. Robert C. Batterman, reported recently in the *Journal of the American Medical Association*.

Using an improved form of organic gold compound, aurothioglycanide, over an eight-year period, Dr. Batterman found that gold therapy,

which in pre-cortisone days had been criticized for slowness in producing improvement and for toxicity, is suitable for use even since cortisone and ACTH have been discovered.

In 56% of his patients with early arthritis, the gold compound gave complete remission or major improvement. The treatment is less toxic than any other available gold compounds.

Chromatography Solves The Rare Earth Problem

Analyzing For All the Elements

Group III, a and b, Lanthanides and Actinides

► A CHARACTERISTIC compound of all Group III elements is the gelatinous white hydroxide. Many elements are precipitated in that form. A bulky white precipitate when the acid solution of a metal or mineral is neutralized with ammonia may mean a mixture of elements. If the rare earth metals are present, their separation should be attempted by the new ion-exchange column method rather than by the older method of fractional crystallization.

The chances are that in most compounds analyzed, the appearance of a white flocculent precipitate when the acid filtrate from the sulfides is neutralized with ammonia means aluminum. However, it is the object of this series to tell where the elements would come down in the analytical scheme, if present.

As will be noticed in the table of test reactions, all the Group III elements, in both subgroups, are remarkably alike in the behavior of their usual compounds. Even gallium, which precipitates as the sulfide from alkaline solutions containing the sulfide ion, comes down as a white precipitate which would be difficult to tell from the white hydroxides of the other group elements, if they were present. Thallium sulfide, by contrast, is black.

The "periodicity" of the Periodic Table of Elements is shown by the shift of properties from alkaline, or

basic, to acid with increase in atomic mass and number, from Group I through Group VII, and back. Just as the elements of Group II are less alkaline than those of Group I, the elements of Group III are less alkaline than those of Group II. They begin to show "amphoteric" properties. Their hydroxides are neither bases nor acids, but show some of the properties of each class of compounds. Boron is the first element which is determined as an acid in the qualitative analysis scheme. Aluminum hydroxide is less of an acid, in accordance with the general rule that, in all groups, the elements become more metallic and more basic with increase in atomic weight.

The "rare earths" (the lanthanide series) and their analogues, scandium and yttrium, were a puzzle to chemists for 150 years. Their compounds were studied in great detail in an effort to find chemical means of separating them. The fluorides, the carbonates, the alkali double sulfates and the dimethyl phosphates each give some separation. There is a difference of solubilities of the corresponding salts of each element of the series.

All such separations require a tedious course of fractional crystallizations. The first crystals to form are set aside as the first member of the series, richest in the least soluble salt. A middle fraction is then allowed to

Group III. Elements in Test Reactions

	HCl	H ₂ S	(NH ₄) ₂ S	(NH ₄) ₂ CO ₃	Special Test
III.a.					
B	—	—	—	—	Conc. H ₂ SO ₄ + methyl alcohol gives volatile compound which colors flame green
Al	—	—	Al(OH) ₃	—	—
Sc	—	—	Sc(OH) ₃	—	Spectrum
Y	—	—	Y(OH) ₃	—	Spectrum
La*	—	—	La(OH) ₃	—	Spectra
Ac**	—	—	Ac(OH) ₃	—	Radioactive properties
Ga	—	—	Ga ₂ S ₃	—	Two violet lines in spark spectrum
III.b.					
In	—	—	In(OH) ₃	—	Blue line in spectrum
Tl	TlCl ₂	—	TlS	—	Green line in spectrum

* The Lanthanide elements behave similarly in chemical reactions to lanthanum. Their spectra are distinctive.

** The Actinide elements are generally identified by their radioactive characteristics. Their chemical behavior is similar to that of the rare earths, but they display a greater variety of valences.

crystallize. The liquid left over becomes the fraction representing the most soluble member of the series. The crystals are then dissolved in pure water (or other solvent, if suitable), and again the least soluble crystals are reserved, while the middle portions are combined, and the most soluble salts become concentrated in the remaining mother-liquor. Hundreds of such recrystallizations are required to obtain the rare earths in even moderate purity.

With the development of ion exchange resins as an extension of the method of chromatography, a new tool has been found for separation of the rare earths. It is by far the most successful general method yet found for the purpose. A cation type exchange resin is packed in a long tube. A solution of mixed lanthanide elements in dilute acid is allowed to trickle down through it. Then a 5%

solution of citric acid is poured through the column to elute (wash out) the salts which the ion exchange resin held back from the first solution. It has been found that the elements march out in order of their atomic numbers. It is only necessary to catch the liquid dripping from the tube in a succession of small flasks to obtain solutions of the different elements, each fairly pure and capable of re-purification by the same means.

The atomic pile turns out appreciable quantities of the rare earth elements as fission products. Since their purification has become so much simplified by the ion exchange technique, it is possible for the first time to have accurate data on such elements as promethium, gadolinium, even the mysterious Element 61, one of the few believed not to exist at all in nature.

Before the production of the man-made elements heavier than uranium,

many chemists believed that thorium should fit into the Periodic Table in Group IV. They thought that the little-known Protactinium should belong in Group V, and that uranium should be placed in Group VI, in spite of its dissimilarity to chromium, molybdenum and tungsten. Recent discoveries have corrected these errors, and established the new series of actinide elements corresponding element for element with the rare earths. The six man-made elements added to the three natural ones beyond actinium, carry the series through the analogue of Dysprosium, leaving five more of the actinides to be created by nuclear bombardment.

Radioactive elements, like the actinides, are recognized by the type of radiation given off, and its half-life. Instruments for measuring the radiations have been greatly improved since the discovery of atomic fission. Nuclear reactions have become a separate science. Since so much interest in prospecting for thorium and uranium minerals has developed in recent years, descriptions of some of these ores, as compiled by The Canadian Bureau of Mines, are added here.

Radioactive Minerals

►THE NUMBER of known minerals which contain uranium in some amount is quite large—over fifty species are listed—but the great majority of these are rare and can be considered at present of only mineralogical or specimen interest. In many, also, the uranium present is not an essential constituent, but is more in the nature of an accidental impurity, and the content of the element is so low and so variable that these minerals

are of small practical importance as a source of uranium.

Primary Minerals

Primary uranium minerals are dominantly black, conspicuously heavy, and of a metallic or sub-metallic appearance.

Pitchblende, the richest and most important, is compact and massive, with no evidence of crystal form or structure. It sometimes is found with botryoidal, or kidney-like, surfaces and a radiated texture. Pitchblende is distinctly a vein-forming mineral and is usually associated with cobalt, nickel, silver, and copper.

Almost all of the other primary uranium minerals, including *uraninite*, a crystal variety of pitchblende, are confined in their occurrence to granitic rocks, more especially to pegmatite, which is a "giant," dyke-forming type of granite in which the chief component minerals, feldspar, mica, and quartz, occur in large crystals or masses. The variety of uranium minerals found in such association is large, and for the most part these are of complex compositions, being multiple oxides of uranium, tantalum, columbium, titanium, iron and the rare-earth elements. They are mostly black to dark brownish-red in color, conspicuously heavy, often of a sub-metallic appearance, and usually occur in the form of well-developed crystals up to several inches in length. It is characteristic of such minerals that the rock enclosing them is usually stained or coloured a deep brownish red, and any patches or zones of conspicuously reddish colour in a paler pegmatite groundmass are worthy of examination for the possible presence of uranium minerals. Sometimes, also, small

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traces of conspicuously coloured canary-yellow or orange powdery crusts of secondary uranium minerals occur surrounding such crystals and serve to confirm their nature. It is not uncommon for pegmatitic uranium minerals to be concentrated in zones containing large nests or aggregates of black mica, and the rock around such mica, as well as the mica crystals or books, themselves, should be given particular examination. The occurrence, also, of a black, coal-like hydrocarbon mineral (thucholite or anthraxolite), which will burn, in a pegmatite is suggestive of the presence of uranium, and this material, itself, often contains a considerable amount of the element.

As a rule, such minerals occur rather sparsely disseminated in the host rock, though occasionally they form small nests or pockets. Owing to their complex composition, which would make chemical treatment for recovery of the contained uranium difficult and expensive, their variable and often only small content of uranium, and the usually limited quantity present, they can be considered as of only problematic value as uranium ores. However, it is of decided interest to have all new discoveries of such minerals placed on record, in case it may prove desirable to have the occurrences investigated more thoroughly at a future date.

Thorium Minerals

It is not uncommon for certain primary uranium minerals, more especially those found in pegmatites, to contain moderate amounts of thorium. Certain varieties of *uraninite*, the crystal form of pitchblende found only in pegmatites, are fairly rich in thorium, but, on the whole, straight thorium minerals which might be regarded as

commercial sources of the element are much less common than uranium minerals and only a few are known. Most of even these few are of rare occurrence and of only mineralogical interest, and up to the present practically the entire world supply of thorium has been obtained from the single mineral *Monazite*.

Monazite

Monazite is of complex composition, consisting mainly of cerium and other rare-earth elements, with up to 18 per cent of thorium. It is a non-metallic mineral, yellow to reddish brown in colour, conspicuously heavy, and of crystalline character. It occurs as tabular crystals in pegmatite dykes, and as small grains in rocks intruded by granite or pegmatite, but most of the commercial supply is obtained from rich concentrations formed by wave action in beach sands along the coasts of India, Brazil, and Australia. Similar beach deposits are known in Ceylon, Florida, Malay, and the Netherlands Indies, all of which have furnished small quantities.

It is doubtful if occurrences of monazite in rock would be of economic interest at the present time, but such occurrences are worthy of record and might be of value as indicating the possible presence of nearby placer deposits, particularly if they exist in coastal areas.

Any extensive beach sand areas conspicuously rich in heavy black minerals are worthy of sampling for a possible monazite content. The black metallic mineral in such sands is likely to be *ilmenite*, an important ore of titanium, and often associated with it are *rutile* and *zircon*, both valuable industrial minerals.

Other Thorium Minerals

The richest thorium mineral known is *thorianite*, a heavy, black metallic mineral which occurs in small cubic crystals in pegmatites. It is known in commercial amounts only in alluvial placer deposits, and is an exceedingly rare mineral, whose principal source is Ceylon.

Allanite is a complex mineral containing cerium and other rare earth elements; it may carry up to 3 per cent thorium. Its occurrence is confined to pegmatites and granite, and in the former it is sometimes found in very large crystals. *Allanite* is a heavy, non-metallic mineral, black when fresh, but usually altered externally to a brown colour. An outer brown and friable crust is typical for *allanite*, and usually serves as a ready means of identifying it. While *allanite* has not so far come into consideration as a commercial source of thorium, it might serve as such if found in sufficiently rich deposits. For this reason any new discoveries of the mineral are worth placing on record.

Thorium is not precipitated out of solution in circulating waters, as is uranium, and hence important deposits of secondary thorium minerals are unknown, or are of relatively small importance. Small traces of thorium occur in the sinter of certain radioactive springs in Germany, France, and other countries, and in some cases recovery of thorium has been made from such sources. In view of the relative abundance of monazite, however, this mineral, as well as perhaps other primary thorium minerals, originating in pegmatitic or granite rocks, is likely to remain, for the present at least, the most important source of the element.

Radioactivity Methods

All minerals containing uranium/thorium are radioactive; that is, they emit energy in the form of spontaneous radiation, and this may be detected by several fairly simple means. It is not possible, however, to distinguish between the emission from the two elements except by precise laboratory methods. Close geochemical affinity, also, exists between the uranium and thorium, and many minerals containing either element—more especially the pegmatitic species—frequently carry the other as well, in which case the radiation is of a dual nature, and may lead to wrong conclusions being drawn.

Photography—One of the simplest means for detecting radiation from minerals is to place the specimen on an ordinary photographic plate or film in a light-tight box and allow it to remain undisturbed for about 36 to 48 hours. On developing the negative, any marked uranium/thorium content will be evidenced by a distinct image, or auto-radiograph of the specimen. Intensity of such image, or self-photograph, is a rough measure of the degree of radioactivity of the mineral, and thus of the amount of uranium/thorium present. This amount, in turn, governs the time of exposure required to produce a well-defined picture. To avoid possible misleading effects due to pressure or chemical action on the photographic emulsion, it is sometimes advised to interpose a thin sheet of paper between the specimen and the film. Production of a smooth face on the specimen by sawing or grinding is advantageous and results in a much clearer and more defined image being formed.

Recent refinements in the making of radiographs of mineral specimens employ a special type of light-desensitized film. This distinguishes between uranium and thorium radiation, when both elements are present, by the relative intensity of the image.

Visual—For many years, a simple means of detecting radioactivity in minerals in the field was by the use of a small pocket device known as a *spinharscope*, or *scintillscope*. This consists of a short brass tube provided with a cap bored with a small hole in which a magnifying lens is inserted. Below the lens is cemented a small square glass prism, the lower end of which is coated with zinc sulphide powder. If a small fragment of strongly radioactive mineral is held close to this coated surface, some of the radioactive particles emitted impinge on the grains of powder and cause a succession of momentary flashes of light, readily seen through the lens. For best effect, it is necessary to conduct the experiment in a dark place, and to have the observer's vision thoroughly adjusted to darkness for a period of several minutes.

One of the most reliable and widely-used instruments for detecting and measuring radioactivity has long been the *gold-leaf electroscope*. This makes use of the property possessed by radioactive materials of releasing the electrical charge on two small strips of gold leaf through ionization of the air in a small chamber in which they are suspended. By comparing the rate of discharge effected by a measured quantity of powdered and carefully sized material made from an unknown sample with that produced by a similar amount of a standard of known

composition, a fairly close and rapid estimate of the degree of activity, and hence of the uranium content, of the test sample can be made. By such means, a great deal of time-consuming chemical analytical work can be eliminated, particularly in mills and refineries engaged in producing and treating uranium ores. Any thorium present in the test samples of course destroys the efficiency of the method, since thorium is much more active than uranium. For reliable results, the electroscope requires to be employed in a laboratory and is hardly suited to field use.

It is sometimes stated that the portable *ultraviolet light lamp* is a useful tool in prospecting for uranium minerals. This is true to a limited extent only, since only certain of the secondary species, and none of the richer primary minerals, exhibit any fluorescence under ultraviolet light, whether short or long wave. The utility of the lamp, therefore, would be confined to a few fluorescent secondary minerals, only one of which—*autunite*—has so far been found to occur in sufficient quantity to be of any particular economic interest.

Electronics—The above-mentioned, and, by comparison, relatively crude means of detecting or measuring radioactivity in minerals or other substances have more recently been supplanted by much more delicate and precise methods provided by an instrument known as the *Geiger counter*. This is a device employing radionic principles, whereby radioactive emission can be directly registered, measured, and recorded, either in the form of sound or in other ways.

Dead Bones Live Again By Chemical Treatment

Enzyme Controls Bone Calcium

➤ APPARENTLY dead bones have been revived and endowed with twice the ossifying power they had before their destruction in experiments reported by Dr. Albert Edward Sobel of Brooklyn, N.Y., at the joint meeting of the American Chemical Society's Chicago Section and the American Association of Clinical Chemists.

Diets that reduced tooth decay in laboratory animals by 75% in extent and severity were developed in the same research.

Improved control over abnormal bone formation and more skillful treatment of bone wounds are foreseen as a result of this fundamental work.

It all started when Dr. Sobel and associates in the chemistry department of the Jewish Hospital, Brooklyn, studied the composition of new mineral deposited in bits of living bone from solutions containing the mineral ingredients of bones and teeth. These are calcium phosphate and calcium carbonate.

From carbonate-rich solutions the mineral which came out was rich in carbonate. From phosphate-rich solutions it was richer in phosphate. From this information, diets were designed to produce blood rich in carbonate or rich in phosphate. The diets were then fed to cotton rats. These laboratory animals are susceptible to dental caries closely resembling tooth decay in humans. The high carbonate-low

phosphate diet produced teeth high in carbonate. The low carbonate-high phosphate diet produced teeth low in carbonate.

Because acids produced in the mouth can dissolve the calcium carbonate portion of tooth minerals without dissolving the other tooth mineral, calcium phosphate, Dr. Sobel expected the teeth high in carbonate to be more susceptible to decay. This was the case. The animals with good tooth composition had only about one-fourth as much tooth decay as those with poor composition and the decay in each tooth was less than one-fourth as great in well constructed teeth.

The revival of dead bone cells was done with bits of bones taken from living animals. The bone cells were apparently killed by treating them with salts of magnesium, copper, beryllium, strontium and ordinary table salt. These salts destroyed the mineralizing power of the bone cells, whether there was a lot or no calcium present.

The bone cells were then revived and their ability to mineralize was restored by treating them with calcium chloride. The bone cells can be revived up to half a day after their apparent death and possibly after a full day.

An enzyme, Dr. Sobel and associates found, plays a big part in governing the mineralization of bone. This

enzyme cannot work unless it combines with calcium. But other salts, like copper, beryllium and magnesium, can compete with the calcium to combine with the enzyme. When they succeed they block the ability of the cell to ossify, or form new bone cells.

Shaking the bone cell with a calcium salt when none of these other salts is present makes the "marriage" of calcium and enzyme take place at a greater rate than under normal conditions in the living body. The result is that the revived cell has a greater ability for mineralization than before.

Food Poisoning Depends on Body

► THE POSSIBILITY that whether or not a person gets food poisoning depends on the state of his body chemistry is suggested in experiments reported by Drs. L. Joe Berry and Roland B. Mitchell of Bryn Mawr College, Bryn Mawr, Pa., and the USAF School of Aviation Medicine at Randolph Field, Tex.

Altering body chemistry to block that part of it called the citric acid cycle, these scientists found, made mice very much more susceptible to infection with the germs called Sal-

monella typhimurium. These germs cause disease in mice and also food poisoning in man.

Mice that had their citric acid cycle blocked by injections of sodium malonate died within eight hours after doses of Salmonella which do not cause casualties among normal mice until the third day. The sodium malonate by itself would not kill the mice in the doses used. Details of the experiments were reported in the journal, *Science*.

Anesthetic More Active than Cocaine

► POTENT local anesthetics can be made even more active by substituting sulfur for carbonyl oxygen atom in the molecule, scientists at Sterling-Winthrop Research Institute, Rensselaer, N. Y., have found.

One of the new anesthetics they have produced is 1,000 times more active than cocaine when applied to the cornea of a rabbit's eye. When used as a spinal anesthetic for rabbits, anesthesia lasted twice as long

with about one three-hundredth the dose as compared with procaine.

With the increase in potency went a greater margin of safety with regard to both irritating effects and general toxicity.

The new, potent local anesthetic is known so far only by the code name, WIN 4510. Details of its chemistry, testing and other related compounds are reported by Drs. F. P. Luduena, R. O. Clinton and S. C. Laskowski in *Science*.

Thickeners For Petroleum Grease Startlingly Like Ordinary Dirt

Sand in the Gears

Reprinted from the Industrial Bulletin of Arthur D. Little, Inc.

► SINCE THE invention of the wheel, man has been plagued by the problem of lubricating the bearing on which it rotates. Today, even the usual automobile service station must stock several kinds of grease to meet the variety of destructive conditions found in the machine. Recently, however, new greases thickened with solid materials rather than with the standard soaps have appeared; they stand up well enough to carry the industry closer to the ideal of the multi-purpose lubricant. These products are expensive, but one of the newest solid thickening materials, processed Fuller's earth, is expected on the market within six months and may be cheap and sturdy enough to replace many of the special-purpose products.

Most lubricating problems, except for those caused by actual lack of lubricants, arise because the grease escapes from the bearing. Better bearing design can help to prevent this, but a grease that will not become too fluid when hot or too stiff when cold is still required. For centuries, animal fats and other natural products—even wood pitch—have been the prime semi-solid lubricants or greases. Lime soaps were used to grease the bearings of an Egyptian chariot as early as 1400 B.C., but little further progress was made from then until the industrial revolution, when higher speeds and greater bearing pressures made improved lubricants necessary. The first

"modern" greases were developed in the 18th century, and in the latter part of the 19th century petroleum-based lubricants began to appear.

Today, greases are made chiefly of petroleum lube oils converted to a grease-like consistency with a gelling agent, usually a soap, much as water is gelled by gelatin. For some uses, sodium soaps, similar to household soaps, are adequate; calcium, barium, aluminum, and other metallic soaps are needed for other kinds of greases. Some of the newest and increasingly popular greases are prepared with lithium soaps, and seem best able to withstand extreme temperatures. Despite much development effort, however, no one of the soap-based greases can withstand all the conditions of heat, cold, water, corrosion, and other extremes encountered in the hundreds of applications required of greases. Specific formulations for each of these problems have been needed. In recent years, of course, other types of lubricants have been developed for special applications. Among these are the silicone greases, molybdenum-disulfide powder additive, and modified oils for conditions of extreme pressure. Because of either cost or limited areas of application, however, these materials are not suitable for widespread use.

Some of the new solid-type thickeners for petroleum lube oils bear a startling resemblance to ordinary dirt, the last thing one would normally put

into a bearing. They are, however, composed of such fine particles and are so highly refined to find them of abrasive materials that they do not contribute to bearing wear. Their chief value lies in their remarkable ability to convert petroleum oils to a desirable gel. Bentonite, silica aerogel, and, more recently, other forms of silica as well as special types of colloidal Fuller's earth have been found to possess this property. Of these solids, only one, the silica aerogel, is made artificially; the others occur naturally.

When these solids are properly dispersed in lubricating oils, using surface active agents, the resulting greases have a wide range of uses. They show no softening with increasing temperature up to the point where the oil actually distills from the gelled mixture, or burns; they stand up well

under shearing stress, and those prepared from Fuller's earth give outstanding corrosion protection and resist breakdown by oxidation. With properly prepared grease, moreover, there is no increase in bearing wear over that shown by the usual soap-thickened greases. The new types, although not yet fully developed, are probably the nearest approach to a multi-purpose grease now available.

Both the silica aerogel and the bentonite-type thickening agents are on the market now. They are, however, rather expensive, and have been used only where top performance is required. Colloidal Fuller's earth, by contrast, has proved equally as effective as the others, and may be substantially cheaper. Its use is expected to expand applications for the solids-thickened greases much more widely in the future.

Crystal "Quakes" Reveal Secrets

► SCIENCE is learning more about earthquakes, the earth's interior and petroleum deposits by observing small-scale, man-made "quakes" generated in a laboratory by a pulsating crystal of lithium sulfate.

The tiny tremors are being used in a study by Dr. Leon Knopoff and Glenn Brown of the Institute of Geophysics on the Los Angeles campus of the University of California.

Many of the important features of earthquakes and seismic prospecting procedures may be reproduced on a small scale in laboratory models. This enables scientists to study seismic

phenomena under known and controlled conditions.

The pulsating crystal of lithium sulfate sends "microquakes" through blocks of granite, wax or cement at the rate of 1,000 per second. The shock waves are reproduced on an oscillograph and recorded photographically for detailed studies.

Seismic waves at present are the most important means of exploring the earth's interior, Dr. Knopoff declared. Through such laboratory studies he hopes to develop better seismic prospecting techniques and better methods of interpreting seismographic data.

Chemical Problems Encountered In Improving Standard Textile

Denim Renaissance

Reprinted from Dyelines and Bylines, American Cyanamid Co.

► THAT TRIED and tested work horse of the low-priced cotton fabric field, denim, has acquired new looks and greatly increased consumer appeal through the incorporation of the many varied hues of fast vat and azoic dyes and of man-made fibers into the field formerly occupied by the staple indigo-dyed or sulfur black-dyed all-cotton fabric. Textile trade literature is filled with promotions of these new denim fabrics for sport shirts, slacks, blouses, zippered jackets, skirts, work clothing, and similar apparel. These new denims fill the need for durable and attractive apparel at a cost between that of the drab but very low-cost indigo or black denims and the beautiful but rather expensive fast dyed twills, gabardines and poplins.

When low cost is the most important factor, there is still, after many centuries from antiquity to the present, no dye of comparable hue, tinctorial power, and fastness to supplant indigo. It is dyed on warp yarn in huge machines which run continuously with very little labor and which produce some 24,000 pounds of dyed warp every 24 hours, equivalent to about 100,000 yards of denim. To displace a portion of this low-priced market with faster shades in many hues has required intensive effort to cut dyeing and manufacturing costs attendant upon the use of vat and azoic dyes so that the consumer market would admire and buy rather

than admire and then walk away with wistful looks.

Several methods are now widely used to dye vat and azoic dyes on warp yarn for denim.

In one method, 200 to 300 pounds of yarn are wound on dye-beams, large metal spools with a perforated core. These dye-beams are placed in metal kiers and dye liquor is circulated through the yarn, cyclically, from center to outside and from outside to inside of the dye-beam. Vat and azoic dyes are thus applied with efficient use of color, steam, water, chemicals, and labor.

In another method the above batch procedure is replaced by a continuous procedure. Up to 24 warps, each containing 400 or more yarns 15,000 yards long, pass in parallel formation through various steps of the dyeing process finally ending up dry and ready for subsequent manufacturing steps.

In a third procedure, warp yarn is fed as a flat web of parallel strands from several large spools called section beams. It passes through the various dyeing steps in a continuous procedure and finally is delivered ready for the loom as a warp beam, a huge wooden or metal spool containing warp yarn from several section beams. Wide range of fast and vivid dyes has spurred the wide acceptance of denim for many apparel fields.

Inventions Interesting to Chemists

Patents may be ordered by number from the Commissioner of Patents, Washington 25, D. C., at 25 cents a copy. Remittances should be sent in coin, money order, U. S. Patent Office coupons, not stamps.

Conducting Glass Sandwich

► AN ELECTRICITY-CONDUCTING glass sandwich has been patented that is fortified against operational failure. This may come as good news to the aircraft industry which uses electrically heated glass in airplane windshields.

The safety glass invention involves two sheets of glass, one of which is coated with an electricity-carrying film such as tin oxide. Sandwiched between the panes is a plastic filler separated from the glass panes by special tape or strip material located at the margins of the unit.

The special tape and strip material sharply cut chances of operational failure of the glass, report inventors Romey A. Gaiser and James H. Boicey, both of Toledo, Ohio. Thus when current flows through the conductive layer, the high temperature created there, contrasted with the "inside" room temperature and a possible sub-zero "outside" temperature, will not cause an electrode failure within the unit due to difference in expansion of the glass-sandwich elements.

The inventors assigned their patent, No. 2,650,976, to Libbey-Owens-Ford Glass Company, Toledo.

Radiant Heating System

► A RADIANT heating system for houses has been developed that warms occupants in the winter, cools them in the summer, yet does not materially heat or cool air in the house.

The radiant heat exchanging system depends upon electric heating elements and cooling coils of Freon, both of which are nestled in a shallow cornice encircling each room near the ceiling. Walls and ceiling of the room are covered with a heat-reflecting foil coated with a colorful lacquer.

In the winter, the heating coils generate heat which bounces from the ceiling and walls in all directions, being absorbed by occupants of the room. This makes the occupants feel warm, even though the air may be somewhat chilly. In the summer, the occupants act as the heating elements. Their body heat bounces off walls and ceiling until the heat rays strike the cooling coils which absorb them. This transfer of heat from the body to the cooling coils makes the occupants feel cool.

The radiant system of heat exchanging was invented by Dr. Clarence A. Mills of Cincinnati who assigned his patent, No. 2,651,503, to Reflectotherm, Inc., also of Cincinnati.

Plate Glass Carrier

► A LEATHER harness has been invented to help workmen who must carry panels of plate glass, slabs of gypsum or other large and unwieldy

blocks of building material. The harness has a saddle that hangs just above the workman's right knee. The edge of the panel rests in the saddle and the panel leans against the workman's shoulder. Using his free hand, the workman can carry the panel easily even in buffeting winds. If some obstruction temporarily blocks his path, the workman merely kneels down and unhitches the saddle. Then he can stand up and steady the panel. The saddle prevents its edge from becoming muddy. Designed to be used by pairs of workmen, the harness was invented by Robert S. Rau of Fanwood and Winfield Rau of Chatham, N. J., who assigned their patent, No. 2,651,441, to the Atlantic Builder's Supply Corp., of Chatham.

Titanium Rolling Process

► **TITANIUM**, a rugged, lightweight, heat-resistant metal with growing implications in the jet aircraft business, now can be turned out in light-gauge hot-rolled sheets comparable to sheet steel.

A method of rolling the sheets received patent No. 2,651,099 this week and involves rolling titanium ingots into sheet bars, descaling the surfaces, repeatedly heating and elongating the bar by single-ply rolling until it reaches the heavy-sheet form, then rolling these sheets in pairs until they become very thin, sandwiching them between basic steel sheets and reheating and rolling the "sandwiches" until the desired thickness has been obtained.

By this method, sheets of titanium can be produced that are three feet wide, eight feet long and two one-hundredths of an inch thick. Until now, producing titanium sheeting has

been seriously hampered by the metal's unusual ability to oxidize at the high temperatures needed to work it.

The method was developed by James A. Roemer of Warren, Burt H. McKibben of Niles, and Joseph R. Corry, of Mineral Ridge, Ohio, who assigned their patent to the Mallory-Sharon Titanium Corporation, Niles, Ohio.

Cleaning Mitt

► **HOUSEWIVES** soon may have a watertight cleaning mitt to use while scrubbing pots and pans. The mitt can be worn on either hand and protects the flesh from harsh abrasive material and slivers of steel wool. Cleaning pads clip to it. Dora Frances Dyer of Astoria and Herbert A. Coe of Port Washington, N. Y., received patent No. 2,651,071 on their invention.

Flavoring Device

► **JOSEPH L. RISCO** of Los Angeles received patent No. 2,652,765 on a flavoring device for housewives to use to add tangy seasoning to meat. It consists of a chamber to hold condiments and other flavoring materials, and a carrot-shaped probe riddled with holes. The probe is pressed into the meat before cooking. Heat of the oven builds up pressure inside the device, forcing vapors of the seasoning through the probe and into the meat. The device is protected from exploding by a special pressure-relief valve.

Boiling Point Indicator

► **THE BOILING** point of a crude liquid is a good indication of just what it is. In manufacturing chemicals, people heretofore were always drawing off

samples, bringing them to a boil and then throwing them away. This was not only wasteful, it was also sometimes inaccurate because the air pressure on the sample might not be the same as the air pressure on the material going through the pipes and vats in the manufacturing process.

Now a Du Pont man has invented a method for determining boiling points in a chemical manufacturing setup which returns the sample material to the process and which eliminates the error factor.

He does this by providing an independent closed testing circuit which automatically maintains its internal pressure and temperature, automatically and continuously determines and maintains a record of crude product boiling points. It also automatically returns the test material to the manufacturing system without interrupting the progress of the manufacturing process.

Frederick L. Shands, Newburgh, N. Y., received patent number 2,639,609 for this and assigned it to E. I. du Pont de Nemours and Co., Wilmington, Del.

Sikorsky, McMillan Patents

► TWO WELL-KNOWN inventors have received patents from the government. They are Igor I. Sikorsky, inventor of the helicopter, and Dr. Edwin M. McMillan, inventor of the atom-smashing synchrotron.

Mr. Sikorsky received his patent for a combined clutch and fan for a helicopter motor. The patent, number 2,640,469, was assigned by him to the United Aircraft Corporation, East Hartford, Conn. The blades of the fan are connected to the periphery of

a plate member comprising the main element of the driving portion of the clutch.

Dr. McMillan invented a new accelerator target. In a synchrotron, he explains, a beam of electrons is directed upon a thin target which thereby produces a narrow beam of X-rays. However, only a small portion of the beam energy can be converted into X-rays with this thin target. Dr. McMillan has constructed a thick target which will convert a greater part of the electrons into X-rays but which will not disrupt the electron beam.

His patent, number 2,640,924, has been assigned to the Atomic Energy Commission. Dr. McMillan is at the University of California.

Scrambled TV

► A METHOD of sending scrambled TV pictures during wartime received patent No. 2,636,936. Invented by Dr. Alfred N. Goldsmith, chairman of the board of technical advisers for the Radio Corporation of America, New York, the system presents a jumble of light on video screens unless the receiver is equipped with an oscillator to straighten out the picture. The method can be used in pay-as-you-see-it TV areas to prevent non-subscribers from watching the program without cost. Dr. Goldsmith assigned his patent to RCA.

RCA also was assigned patent No. 2,636,671 covering a radio and TV audience-counting system invented by Robert Evart Shelby of Teaneck, N.J. The system reveals how many radio or TV sets are tuned to a given station. It eliminates the need for surveying the audience by telephone or for house-to-house visits.

Book Condensations

INORGANIC CHEMISTRY: A Text-Book for Advanced Students—E. de Barry Barnett and C. L. Wilson—*Longmans, Green*, 512 p., illus., \$7.00. The elements and their more important compounds are described according to the Bohr classification.

GENERAL COLLEGE CHEMISTRY—Frank Brescia—*Blakiston*, 581 p., illus., \$6.00. For the first year college science and engineering students.

CHEMISTRY AND METHODS OF ENZYMES—James B. Sumner and G. Fred Somers—*Academic Press*, 3rd ed., 462 p., illus., \$7.50. An introduction to enzyme chemistry for advanced students and research workers.

ANALYSIS OF ALUMINUM ALLOYS: A Compilation of Modern Methods—G. H. Osborn and W. Stross, Eds.—*Chemical Publishing*, 144 p., illus., \$3.50. A survey of analytical methods, many of which are new or modified versions, and a few are established standards.

HISTORIC RESEARCHES: Chapters in the History of Physical and Chemical Discovery—T. W. Chalmers—*Scribner*, 288 p., illus., \$5.00. Intended as a background for modern physics and chemistry, this work covers friction, X-rays, atoms, etc.

ATOMS AND ENERGY—H. S. W. Massey—*British Book Centre*, 173 p., illus., \$3.50. The scientific basis for the development of modern atomic weapons as well as the production of power from atomic energy. The author also evaluates present-day research on the relations between matter and energy.

THE CHEMISTRY WE USE: Experiments For the Home Lab—Burton L. Hawk—*Science Service*, 87 p., illus., \$2.00. About the chemistry of things most of us just take for granted—air, food, water, clothing, and so on.

REFINING OF OILS AND FATS FOR EDIBLE PURPOSES—A. J. C. Andersen—*Academic Press*, 204 p., illus., \$7.00. Some animal fats such as suet and lard and some vegetable oils, when rendered by appropriate methods, can be used for food without further treatment, but in many cases they must be further refined to remove impurities or traces of toxic materials.

STEWART'S SCIENTIFIC DICTIONARY—Jeffrey R. Stewart assisted by Frances Elizabeth Spicer—*Stewart Research Laboratory*, 4th ed., 788 p., \$10.50. For manufacturers and others concerned with the materials used by the various chemical process industries. The scope of this edition has been greatly widened.

CHROMATOGRAPHIC METHODS OF INORGANIC ANALYSIS: With Special Reference to Paper Chromatography—F. H. Pollard and J. F. W. McOmie—*Academic Press*, 192 p., illus., \$5.50. Providing an introduction to the subject in non-mathematical language and enough practical details so that the beginner can perform experiments.

PROBLEMS IN ORGANIC CHEMISTRY—Edward G. Rietz and C. B. Pollard—*Prentice-Hall*, 332 p., \$3.95. Intended for use with a standard organic course and planned to eliminate some of the student's after-class perplexities.

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- "FROM ART to Science in Envelope Manufacturing" is the title of a booklet by P. B. Davidson, published by Mellon Institute, which discusses the application of the science of high polymers to paper. It is free upon request to the publisher at 4400 Fifth Ave., Pittsburgh 13, Pa.
- **ANALYSTS** will have fewer burned fingers if they adopt the new Kool-Grip Kjeldahl flasks offered by Central Scientific Co., 1700 Irving Park Road, Chicago 13, Ill. Ground cork and a plastic binder cemented to the glass makes a cool grip for the neck of the flask.
- **ZINC DUST** especially low in nitrogen, designed for use in Kjeldahl analysis, has just been brought out by Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa. It can be purchased in 4 oz., 1 lb. and 5 lb. packages.
- **DISHWASHING** by electricity has now come to the lab technician, as well as to the housewife. Special racks designed by the Chemical Rubber Co. for 90% of the most-used pieces of chemical glassware are included in the CRC Labwasher developed for them by the Electric Appliance Division of the Westinghouse Electric Corporation. For further information, write 401 Liberty Ave., Box 2278, Pittsburgh 30, Pa.
- **SHORTENING** the drying time for paints and other coatings is done by a new technique being marketed under the name of "Chem-Dry." Sponsored by the Meyercord Co., the process was worked out by Armour Research Foundation of Illinois Institute of Technology, 13 W. 33rd St., Chicago 16, Ill.
- **PROTECTION** of laboratory workers from harmful solutions that might be sucked into the mouth is built into the new pipettes offered by the Kimble Glass Co., a subsidiary of Owens-Illinois Glass Co. A constriction near the mouth end of the tube holds the conventional cotton plug in place, yet permits easy cleaning. Made in two sizes, of 5 ml and 10 ml capacity, the pipettes are available through laboratory supply houses.

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